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ABSTRACT

PEACESAT (Pan-Pacific Education and Communication Experiment by Satellite) is a demonstration project initiated in 1971. Its objective is to study the benefits arising from direct conference communications between groups with common interests in widely separated nations of the Pacific. Cooperating institutions are linked by low cost, self-contained radio terminals and a communication satellite relay. Each station is able to communicate simply and easily with all others and send and receive voice and facsimile signals. Teletype and slow scan television experiments are also planned. This experimental network is available for use by persons and institutions engaged in research, education, health, and other community services. (Author)

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# The application of satellites to international interactive service support communication

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Peacesat (Pan-Pacific education and communication experiment by satellite) is a demonstration project initiated in 1971. Its objective is to study the benefits arising from direct conference communications between groups with common interests in widely separated countries of the Pacific. Cooperating institutions are linked by low cost self-contained radio terminals and a communication satellite relay. Each station is able to communicate simply and easily with all others and send and receive voice and facsimile signals. Teletype and slow scan television experiments are also planned. This experimental network is available for use by persons and institutions engaged in research, education, health and other community services.

In the Pacific Basin a group of educational institutions from a number of different countries – nine at present – have been using satellite communication regularly in support of health and education activities. They are involved in the Peacesat project (Pan Pacific Education and Communication Experiments by Satellite), designed to determine the value of the communication satellite when applied to the needs of less developed areas of the world. The project uses the U.S. National Aeronautics and Space Administration's satellite ATS-1 and since 1971 has provided an experimental communication system linking institutions and individuals often as far distant as London is from Tokyo.

It is a pleasure for me to represent the participants of the Peacesat project at this meeting of the Royal Society. The project has many of the purposes of the Royal Society: the promotion of international cooperation, the use of experimentation and direct observation, and the development and dissemination of knowledge through discussion. Our conferences over satellite are like this meeting in many ways. Ideas are compared with no commitment as to outcome. Individuals are widely separated physically, in contrast, and would not communicate except for the satellite system.

Most of the nine countries involved in the project are celebrating during the decade the bicentennial of Captain James Cook's visit to their shores, a recognition of the great debt owed to the Royal Society, initiator of this series of voyages of scientific investigation. While transportation and communication have changed greatly in the Pacific since Captain Cook's day, there continue to be the problems of remoteness which greatly affect conditions of life. There are enormous barriers in the way of providing acceptable levels of health and education services in the

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Pacific Basin. Populations are small and separated by vast distances; all social and economic services lack essential resources.

The ability of remote centres to work together and to share capacities is severely limited because communication links in this enormous area are inadequate or unavailable in most instances. This condition is general to less developed areas and the ability to improve limited by cost and terrain – high mountains, great plains, and water. Satellite technology, if properly adapted to economic, political, and geographic conditions, opens new opportunities for solving problems through organized effort.

It is clear, when the actual work is being done, that the small nations and territories of the Pacific cannot separately each sustain complete hierarchical systems for health services and education. Cost requirements, available materials, and the need for specialized professionals will not permit it, as is true for less developed areas generally. To be effective the health and education services in most Pacific Basin nations must be planned and function in relation to a larger multinational working and sharing system based on personal as well as institutional relationships. Telecommunications are essential to the effective functioning of this system and to higher levels of achievement in all areas.

The telecommunications needed should be rapid, interactive, international, low in cost and readily accessible to those in remote areas. The Peacesat project was designed to test and study a satellite system designed to meet these requirements.

Before discussing the project it is desirable to distinguish between three applications of satellites for international communication, each with different purposes, system design, and impact. I will refer to the three applications as common carrier, direct broadcast, and service support.

The first application of the communication satellite was for international common carrier interconnection. The Intelsat system, now well established, provides regular commercial interconnection between the major population and traffic centres of the world. Costly high capacity satellite and ground terminals provide telephone, data, and television circuits for established common carriers that depend for traffic on industry and government, the traditional users of telecommunications.

The second application is more threat than reality today. This is the use of communication satellites for direct broadcast to ground receivers. For some years ahead, power requirements and satellite capacities will prevent wide area distribution of television signals to small, low cost antenna/receivers on the ground. The successful launch by the U.S. National Aeronautics and Space Administration of the ATS-6 satellite, with subsequent demonstration experiments over the U.S. Rocky Mountains and India, represents the most advanced stage of development for direct broadcasting. When use is international rather than domestic, importance is given to the question of national sovereignty debated in the United Nations last year, to which Sir Michael Swann referred in his introduction. But strangely not questioned is the social value of this costly application.

Little has been heard of the third application. This is represented by the Peacesat project and is designed to support educational and social services. In it the satellite becomes a central relay point between small terminals located at points dictated by objectives and operations of the social services involved. A high powered satellite is required in this system without television motion picture capacity in order to permit low cost fixed or mobile ground terminals which can be easily integrated into the working operations of social services. We believe the service support application has great potential for international communication. It can provide immediate assistance to the less developed areas of the world, at the same time it can contribute world wide to the advancement of science, the increased flow of information, and more effective health, education and community services.

In its physical layout the Peacesat experiment consists of a number of satellite ground terminals widely distributed over the Pacific Basin and operated by educational institutions and agencies in several different countries. Regular scheduled communication is maintained for the purpose of conferencing and exchange of information among health, education, and community services personnel.

We began the experiment on the premise that proper design of a communication system should grow out of the operational habits, purposes, and needs of potential users. A demonstration is essential for determining requirements in cultures previously unserved by adequate telecommunications. Such a demonstration is not easy when expensive tools such as the satellite are involved. Fortunately, N.A.S.A.'s ATS-1 satellite was already available. We have sought to bring the needed experience together and test the new technology in natural settings comparable to those expected in the future.

A major problem in the effective application of new technology is that the equipment designers lack knowledge of user needs and responses, while at the same time potential users are an unreliable source of data on future requirements since their knowledge of technical capabilities is limited. This is a greater problem for the less developed world. The technical expert, usually the product of an affluent industrial society, often lacks the experience needed to design effectively for agrarian cultures oriented to tradition. Communication technology is the product of an economic incentive system, and its advocates usually come from outside the country, often sponsored by industries that stand to benefit from adoption and the recurring need for software.

The project seeks to reduce difficulties by providing a link between technology and the users in the field. Emphasis is placed on the inherent characteristics of the satellite: service costs are not greatly affected by distance or terrain as in the cases of underwater cable, wire, and microwave. Wide area coverage allows for a large number of users even if user density is low. And the signal can be provided to potential users, if necessary, without regard to the availability of common carrier or electric power utilities.

The project emphasizes wide area coverage, two-way communication, the use of small, low cost, low capacity ground terminals, and principal participation from remote, less industrial areas with limited resources and special terrain problems. Our concern is with geographical areas where telecommunication is retarded and with information transfer in social areas producing greatest benefits.

The specifications that go to establishing the character of the system are meant to facilitate knowledge flow, adapt to the requirements of health and education, and strengthen the capacity of less developed areas to meet basic human needs. The most important of the specifications are these: (1) All terminals send and receive messages. Transmissions are referred to as 'exchanges' rather than programs. (2) All terminals are owned and operated by the local institutions. This places a local hand on the switch, one responsive to national customs and laws. (3) There is no emphasis on prepared software. Dialogue is the key to utilization and content the product of interaction. (4) Multiple channels will be available in the future to reduce the importance of the gatekeeper and increase social utility. (5) Capital and operating costs are low and equipment is simple.

To meet these specifications only a voice grade signal can be used. Television motion pictures cannot be transmitted but all other mediums can be incorporated as needed. These include voice, facsimile, teletype, slow scan television, wired blackboard, teletype, and computer interconnection.

It is impossible here to describe the many uses made of the system thus far. A few examples will carry the flavour of the schedule.

Pacific-wide epidemic control staff conferences have used the system a number of times a week for about two years to limit the advance of dengue fever. The once mild disease is often fatal today, particularly for children. It is moving out into the Pacific, north from New Caledonia. The advantages of the interactive conference capacity of the system are illustrated in the simultaneous linking for epidemic control of medical officers and field teams in New Caledonia, Kingdom of Tonga, Fiji, Saipan and medical and research specialists at the Pacific Research Section, Honolulu, and the National Institutes of Health in Washington, D.C. Business is transacted rapidly. In a recent session of about twenty minutes it was decided and arranged to fly several patients from the Kingdom of Tonga to N.I.H. in Washington for observation; a doctor in New Caledonia agreed to make a stop in Port Moresby, New Guinea; several reports were made from Honolulu on tests of blood samples provided from epidemic areas; and there was a decision to defer assembly of a local staff group to conform with a doctor's travel schedule. The ATS-1 made possible the intercontinental conference without elaborate switching.

In our first full course for credit an attempt was made to develop low cost educational methods for international, two-way voice transmissions. Audio discourse demands a common language readily comprehensible in spoken form despite dialect differences among users. Students in two geographically separated classes jointly participated in structured learning activities using the Peacesat system. To adapt to anticipated future conditions dependence was placed on peer

teaching. Students played learning games successfully to identify and overcome barriers to interpersonal communication.

Leading U.S. scientists invited to Honolulu at intervals as part of a series on the world in the year 2020, each discussed their subjects in question and answer sessions with audiences assembled in three countries. In Papua New Guinea the national radio service taped and broadcast the transactions on the national radio network.

Newsmen from six separate areas have weekly exchanges of local and regional news stories. These are incorporated into news programs carried by the national radio networks of the countries involved. Local and regional news stories have not been available previously, with news flow determined by the international broadcast services of the major powers.

The regular schedule may be interrupted at any time by medical emergencies. Recently doctors in three countries jointly provided advice to a paramedic attending an injured person in a remote village. The patient survived.

Representatives of the original populations of Alaska, Hawaii, and New Zealand discussed comparative social problems and the ethnic programs in operation in each area.

In Auckland, New Zealand, a specialist on the law of the oceans lectured to classes in oceanography at the University of Hawaii, followed by questions.

In tests with portable teletypewriters, messages were sent and received during periods in which audio discussions were in progress on the system. Data packets have been transmitted successfully between computers during regular audio conferences.

At the request of Niue, recent experience in compulsory school attendance was shared among Pacific legislators and educators.

Questions of government structure have involved the experience of the new, increasingly independent governments of the Cook Islands and Papua New Guinea as applied to the U.S. jurisdictions of Guam and the Trust Territory of the Pacific Islands.

On a suggestion from Tonga, major national poets and writers from several cultures exchanged and discussed their work in a series of often moving exchanges, providing an excellent example of system potential for artistic and cultural development.

Sections of the Royal Society of New Zealand are joining with specialists of other nations in planning effective methods for aiding industrial technology by discussing successful cases of industrial application.

Increased food production has been the object of a year of meetings by tropical agriculture extension officers.

Senior maternity and obstetric nurses throughout the area discussed the interesting and different cultural approaches to child birth and mother–child relationships.

The system is aiding science with its abilities for rapid, direct, interactive

dissemination in the manner of meetings of the Royal Society. A ninety minute conference on remote sensing and earth resources technology satellites, for example, brought together in discussion members of a New Zealand Department of Scientific and Industrial Research, staff members of the N.A.S.A. Goddard Space Flight Center in Maryland, U.S.A., and other specialists at three Pacific locations. One of the participants, a leader in the field from Australia, remarked on conclusion that he had received information which was six months to a year ahead of anything available to him in current printed reports and journals. These activities are representative of the uses to which the Peacesat system has been put since April 1971.

The characteristics of the ATS-1 satellite supported project objectives. It is one of only two satellites in orbit which permits use of a small ground terminal. Its wide area coverage includes most of the Pacific.

The Pacific Basin is well suited to the demonstration. Only the satellite can provide communication to the small, widely dispersed populations separated by water; underwater cable is too costly. There are many small, new nations and the necessity for international cooperation and planning is accepted. The English language is the language of the technically based services and the recognized 'lingua franca'. And there is a wide variety of cultures and environments, both urban and rural. The Pacific Basin is an area that badly needs effective telecommunications and cooperation in obtaining them seemed possible.

The focus of the project and the nature of the satellite system reflect basic purposes, values, and assumptions as to what is desirable, workable and acceptable.

Project attention is limited to experiments in health, education, and community services. Commercial use is prohibited by regulatory authorities. But this limitation is desirable because of the high priority which developing nations attach to improved health and educational opportunity.

The development of telecommunications in this century has followed industrialization with its demand for communication. Growth and system design have been motivated and shaped by industrial and military requirements and controlled by the high technology nations, as is evidenced by a review of spectrum allocations. The Peacesat project, it is hoped, will generate experience to support the contentions that telecommunications for health and education services are of critical importance to less developed areas, that new strategies for growth are needed which do not depend totally on the market economy, and that to support a strong social fabric the establishment of telecommunication services should precede economic and industrial development, not wait to follow.

This is not to suggest that the service support application as described here is useful only to health and education. Very much to the contrary. The economic development of such areas as Papua New Guinea and Indonesia can be facilitated by essentially mobile services available to industrial locations such as mining sites, while public safety, transportation, and conservation activities also require such services.

By design, the project has depended on local effort and financing. It is the sum of individual initiatives rather than the product of central decision making and massive government funding. The project has held to original specifications, although lack of funds means opportunities for study and development are unexploited. In the absence of central financing support, cooperation has depended on personal conviction.

A proposal for the interconnection of Pacific universities and education institution by satellite was first made to N.A.S.A. by the University of Hawaii in early 1969 requesting use of ATS-1. In the Pacific, response to the idea was muted. Several broadside invitations sent to Pacific universities produced a limited response. Some of the educators went to their Post and Telegraph for technical advice and were told that a satellite ground terminal cost several millions of dollars. The 'under $10 thousand' figure provided in the Hawaii letter was hard to accept. They were told further that conditions for an experimental operating licence could not be met in any event. This was not a technical experiment, and a social or educational experiment was not recognized.

To counter this adverse response, Harlan Cleveland, University of Hawaii President, approved $30 thousand for a limited demonstration in Hawaii. Two terminals were designed and constructed by University Professors Paul Yuen and Katashi Nose, and placed on separated islands in Hawaii. With N.A.S.A.'s approval, operation was initiated April 1971. The world's first credit course to be taught via satellite followed shortly.

In the meantime in New Zealand, Anthony Hanley, Senior Tutor at Wellington Polytechnic, pursuing an interest of years, was constructing a satellite ground terminal with the help of students. During tests Hanley heard voices from Hawaii and immediately responded. The first international educational satellite network began operation January 1972 with exchanges between Wellington and Honolulu.

One of those responding to the invitational letter was Colin Aikman, Vice Chancellor, University of the South Pacific – a new multi-national university at Suva, Fiji. The University was establishing remote centres in participating countries and Aikman saw a regional satellite link up with the main campus as adding greatly to the effectiveness of the centres. With the help of grants from the Carnegie Corporation of New York, Alan Cutting of the U.S.P. faculty is directing an extension of terminals to the centres.

In short, project development has depended on initiatives by those close to the societies involved. A group of Tongan students in Hawaii sparked interest in the Kingdom of Tonga. A number of education and health directors observed active ground terminals and returned home to urge local participation. There were no high level conferences, international negotiations among governments, and large budgets. The project has depended on people such as Stuart Kingan, Cook Islands scientific officer, with a lifetime of research in radio wave propagation; George Callison, Trust Territory, a professional broadcaster; Dr Steve Seumahu, Papua New Guinea, a technical educator; Dr Frank Mahony, a social scientist with the

South Pacific Commission in New Caledonia; Margaret Blundell, Kingdom of Tonga, an educator; and Walter Ouye, an educational administrator in Hawaii. The user experiments on the system have drawn in all fields with participants trained in and representative of the nations involved. All this, it seems to me, says something for the system's affect on multilateral cooperation. The value of the investment in telecommunication is in the behaviour set in motion by its use. This depends on the degree of sharing and the will of users to respond to the opportunity. Communication is more than a technical system.

While satellite ground terminals included in the project system are all located in the Pacific Basin, the ATS-1 satellite allows interconnection over a much wider area. In geostationary position at 149° west, the ATS-1 provides a wide area beam that illuminates from 145° east, the midcontinent of Australia, to 60° west, including Cleveland and Washington, D.C. in Eastern United States. Project terminals almost routinely are in conversations involving locations on the extremes of the full service area. Elementary school exchanges, for example, have involved students in New Zealand, Fiji, Hawaii, and rural Alaska. A medical consultation may involve personnel in Saipan, Hawaii, Fiji, Kingdom of Tonga, Alaska, New Zealand, and Washington, D.C. (In 1971 the U.S. National Institutes of Health, Lister Hill Center for Biomedical Communication financed installation of 26 small ground terminals in selected Alaskan villages for use by village health aids. A terminal was also established at the National Library of Medicine, Bethesda, Maryland. Medical and educational experiments have been supported using this array.)

The ground terminals in the Peacesat project are owned and operated by nine different agencies or institutions, licensed by ten different telecommunication authorities, and provide access to a variety of different cultures in nine separate nations or jurisdiction. Ground terminals are located at Wellington, New Zealand; Suva, Fiji; Nukua'lofa, Kingdom of Tonga; Pago Pago, American Samoa; Lae, Papua New Guinea; Rarotonga, Cook Islands; Saipan, Trust Territory of the Pacific Islands; Noumea, New Caledonia; Niue; Honiara, British Solomons; Tarawa, Gilbert and Ellice Islands; and at three locations in the State of Hawaii: Honolulu, Maui, and Hawaii. The University of the South Pacific (Fiji) is establishing four additional stations in as many jurisdictions. Australia is the only major Pacific Basin nation within the satellite coverage area not represented by a terminal.

The ground terminal is simple and effective. The total cost of each unit, including antenna, has ranged from $2500 to $7500 (U.S.), depending on terminal power. The total unit is small, the size of two or three file drawers. Operators have limited experiences for the most part, although technically trained backup persons should be on call. (The ATS-1 has full power e.i.r.p. of 48.0 dBm with transponder receiver noise of 4 dB and transponder antenna gain of 8.5 dB, making possible simple, reliable, low cost, easy to operate and maintain ground terminals. Transponder bandwidth is 100 kHz with four n.b.f.m. voice circuits. Uplink frequency

of 149.22 mHz and downlink frequency of 135.60 mHz permit modification of off-the-shelf v.h.f. equipment that is compatible with the satellite repeater. Crossed dipole yagi and helical antennas are used at different locations. Terminals have linear final amplifiers that range from 100 to 1000 W depending on location. Experience supports use of the higher power.)

Three and a half years have cost under $300 000. This includes ground terminals operating or under development at eighteen locations, as well as operational and personnel costs. There has been little gift equipment, but donated time by participants is important. N.A.S.A. carries satellite control. Half the total cost amount has been provided by the State of Hawaii and the remainder from seven foundations and institutions. (Carnegie Corporation of New York (U.S. foundation), McKenzie Trust (N.Z. foundation), South Pacific Commission, Trust Territory of the Pacific Islands, University of South Pacific (Fiji), Papua New Guinea Technical University (P.N.G.), Wellington Polytechnic (N.Z.). No central government financing has been provided for the system.

Use of the ATS-1 over the period has averaged 18 h a week. Experimentation has been limited by the short lead time on satellite use commitments, as has the number of terminals put into operation. N.A.S.A. has been unable to project satellite availability beyond one year and firm schedules are provided weekly. Many potential participants have been unwilling to risk terminal activation in the absences of longer guarantees; the limiting of terminals has contributed, however, to project manageability. Unfortunately, users also have been unwilling to make major commitments for experiments, except in a few instances, and this reduces project effectiveness.

The mediums of two-way exchange are voice, and until recently, facsimile. E.k.gs and X-rays satisfactory to the medical professional have been sent by facsimile. Limited finance has prevented multi-media experimentation. Clearly, teletype would be valuable. Tests linking computers and computer terminals are under preparation. Slow scan television in which still pictures change every 12 s should have value but has not been tried. The use of additional circuits for feedback signal devices and audience analysis equipment to supplement audio instruction seems desirable.

The focus from the beginning has been on user behaviour to supply the data with which to answer basic questions. What new telecommunication services can be effectively utilized in remote or less developed areas? What improved communications can satellite provide that cannot be provided equally well by conventional telecommunications? What kinds of telecommunication services are probable? What services will be accepted, financed (assuming existing sources and levels), and operated effectively? What kinds of health, education, and community development activities will benefit from new telecommunications.

The approach is to provide an open door for education and health users with a minimum of hurdles and troublesome processes. Some conditions are required by the need to secure data. Preparation of content is left largely to the user.

The structure of the experiment has followed the original plan closely. Educational institutions are ground terminal owner-operators on the assumption that they will be more dedicated to user needs and freer to experiment cooperatively than would line departments of government. Access to the system is determined by agreement of at least two terminals. No sender is scheduled without approval of a participating location. This turns around the broadcast relationship in which management gate-keepers determine materials to be available. The relation is different also in that participants are not passive receivers. The capacity of the satellite for immediate interaction gives the system the valuable two-way characteristics of the telephone, to which are added inherent mobility and remote accessibility.

As originally envisaged, a multi-media studio with an array of communication equipment tied to the transmission link was to be located at each institution. The studio was to serve as a switching point into local common carrier and radiotelephone systems or into institutional dissemination systems such as libraries, clinics, or schools. By centring ground activities the cost of peripheral communication equipment, as well as its operation and maintenance, would be manageable. Users could benefit from the orchestration of media resources. Equally important, a proliferation of ground terminals was to be avoided because of the absence of sophisticated switching within the large region satellite system. In fact, studios vary greatly from rather well appointed settings to part time space used for offices or classrooms. The peripheral equipment has not materialized because of low budgets and imperfect marketing. The concept seems sound however.

A terminal manager at each location acts as an interface between the international community and the local education and health community. He responds to requests for participation from the system and promotes communication relationships desired by those within his community. The terminal manager serves as local experimenter, director of operations, and community leader.

To determine system function, a constant search for users is carried on at each location. Communications proposed by education and health personnel are agreed to by counterparts at other locations. Terminal managers meet at 'proposal inquiry periods' twice weekly to facilitate planning. Users engage in 'pre-planning meetings' followed by 'trials' and if warranted a 'project', with an experimental design extending for many months. The procedure provides data on communication requirements of the social services with the schedule providing a record of declared needs of on-site users. It represents a dynamic approach to software that to date has been very successful. Individuals almost without exception quickly establish common ground and progress is made rapidly.

Growth of the project is the result of three basic characteristics, in my opinion. The technical design is adapted to existing conditions of life. Major social changes are not needed and costs are manageable. Second, organizational design recognized cultural diversity with a high degree of local responsibility and discretion. And thirdly, the system is related to discernible social benefits and to specific opera-

tional requirements. In most instances, the system promises communications that are unavailable without it.

Nothing in our experience so far leads us to reject the basic operating philosophy – that remote areas can be well served by low cost simple equipment on the ground, manned by indigenous personnel working within a coordinated system.

During the past two years, over 1500 persons have actively participated in utilization of the system. Some 350 user-initiated activities have been undertaken, each ranging from 3 to 38 h of satellite time.

We divide uses of the system into seven categories.

*Decision-maker conferences* involve specialists and administrators at several locations discussing topics related to the solution of problems and the implementation of programmes. These have included municipal government representatives, agricultural specialists, health directors, newspaper editors, librarians, and educational administrators.

*Professional and in-service training* was expected to be a major use of the system because of the wide differences in educational resources among metropolitan centres and less populated areas. This expectation has been fulfilled. Everywhere trained personnel are in short supply. Furthermore, professional assignment to a remote area can result in obsolescence because of limited opportunity for continuing education. The system has been used effectively in training of nurses, librarians, dental assistants, agricultural extension agents, teachers, and others.

*Classroom instruction* has included enrichment activities and complete courses. For example, a college course on the foundations of education has been offered successfully by three universities in three nations. A joint staff was used and students received credit from home institutions. Effectiveness could be enhanced by using additional circuits to allow for feedback and visual support such as the wired blackboard, and slow-scan television.

*Community development seminars* involve associations or organized groups seeking to improve the social environment. These have been slow in developing because mutual purpose among widely separated local groups must be recognized first. Groups have been engaged in drug abuse control, land use and environmental issues, and native minority questions. The American Field Service, Rotarians, and parent–teacher organizations, have sought to establish international programme approaches.

*Information transfer* can be improved by simple applications of the satellite system to existing library and data stores. Satellite networking does not have to wait for sophisticated computer served information retrieval systems to provide important benefits. Collections are limited. Transfer is slow and uncertain. As a result, a low ceiling is placed on the development of technologically supported services in remote areas. The first known library network by satellite was in operation in the first months of system use. The average transfer time for materials exchanged between the two participating libraries was reduced from three weeks to four days.

*Professional consultation* is a high benefit application. Medical personnel value this very fundamental application and are unsympathetic to proposals for application of 'space age' sensing devices.

*Public information* experiments show the high promise of a two-way system for international interconnection of national news and broadcast services.

The multiuser concept is basic to a regular wide area low density system such as Peacesat. The development of all possible use is essential. A variety of traffic building networks can be envisaged. By network I mean an agreement for exchange backed by management and standardized behaviour. Networks would be the outgrowth of various organized purposes. They may be institutional as with the University of the South Pacific net, limited to a service as in a medical net, jurisdictional as in a Trust Territory (of the Pacific Islands) net, or defined by equipment as in computer or a radio broadcast nets. The network is a manager of traffic and its relation to the system is transactional. It receives time and in turn provides support for the system.

The University of the South Pacific is using six hours weekly in network relations with terminals located at U.S.P. remote centres. Students confer with instructors; classroom lectures and question–answer sessions are provided in an administratively separate activity. Traffic is building slowly but steadily.

One can see the possibility today of a world health network. It is politically attractive since disease knows no national boundaries and is well suited to the communication practices and deployment of medical and health services.

A medical information search system has been designed for Peacesat in which controllers in Honolulu, the medical centre of the U.S. Pacific, and Wellington, New Zealand assist medical personnel in remote areas of the Pacific by switching information requests to consultants, drawing on local medical library holdings or querying Medlars, the U.S. medical information retrieval system based in Washington, D.C. Satellite time is lacking currently to implement the plans.

An interlibrary loan network plan using Peacesat would link twenty-two libraries in several countries. Discussions over six months via satellite involved representatives of the libraries and produced plans and agreements. Holdings will be queried via satellite by voice. Pages will be returned by facsimile in some instances and airmailed in most instances using microfiche. Printers and readers are to be located at each library. Large traffic is not expected with most requests from scholars. Again satellite time is lacking.

A computer net would combine the concept of addressed switchable data packets and random access to a common communications channel. The addition of the computer brings with it the technical potential for use of available data storage resources. The public service knowledge stores accessible by computer are extremely small today and no good is gained by suggesting otherwise. In future decades when library collections and research data will be accessible from remote computer terminals the value of the long distance transmission facilities will be greatly increased. The objective sought is essentially equal access to knowledge

stores by the scholar or field scientist without regard to location. Computer research programs of the University of Hawaii and Victoria University (New Zealand) are engaged in network and time-sharing studies.

Two-way communication allows for flexibility in radio broadcast station networking suited to international exchange. One radio station can provide or accept programmes from another. Several countries can jointly prepare variety entertainment representative of the cultures in a region. Pacific broadcasters are attracted to satellite exchange for regional news, sports, and music programmes as completed experiments point to important benefits.

Sufficient traffic to support operations among low income scattered populations depends on numbers of uses. Telecommunication for small populations and nations is endangered by 'cream skimming' of two kinds. The development of independent satellite systems for well financed, high priority functions such as health and independent satellite systems by the large less developed countries. Broadly based international initiatives are needed to prevent a premature breakup in the traffic potential which can prevent a workable low density general service support system.

We have come to realize from experience that the development of communication traffic in less developed areas requires cultivation. Where telecommunication has been lacking society adjusts. Any change in procedures will come about gradually. The common carrier traffic studies of the International Telecommunications Union and the U.S. Federal Communications Commission show clearly that there are large areas of the world which produce little traffic. To gain the benefits provided by a new communication resource will require an active programme of user development. It is sometimes said by the telecommunication specialist that where telecommunications capacity is provided it is soon over-subscribed. This has often been the case in the Atlantic and in advanced industrial countries. It is not the case with respect to developing areas or international satellite traffic in the Pacific and the Indian Oceans for example. A period of education is possible only if facilities are available and benefits can be obtained from use. In my opinion such facilities will not pay for themselves for some time. Subsidization of early development is needed.

Without continuing experimentation in service support communication, the satellite is in danger of being associated entirely with cultural invasions and international snooping.

Because of the status of world opinion on direct broadcast of television to home receivers, it is important to make a clear distinction between the communication satellite systems which transmit television motion pictures and a voice grade system, as is used in the Peacesat project. The direct broadcast issue will remain with us for some time with the danger that it may delay international applications of satellites to productive work.

It will be unfortunate if the world is deprived of the versatile service support application because of opposition to direct television broadcasting which by-passes

national authority and operates without public accountability. In contrast, the service support system works through established organizations and is of value to the degree that a cooperative attitude exists among the users.

Surprisingly little has been said on the actual worth of the television medium for developing countries or for international educational communication; and little attention has been given to the cost benefit factors of application.

Compare briefly the voice grade system such as Peacesat with the television system, capable of transmitting television motion pictures. The inclusion of television in any educational satellite programme carries with it important reductions in user manoeuvrability. The voice grade system provides many channels over a large region in contrast to one or few t.v. channels available over a small area. The voice circuit terminals are low cost, portable and easy to operate. Television terminals tend to the opposite.

Software for the voice grade system is largely unnecessary. When prepared it can be done easily and inexpensively by almost anyone even in very remote locations. The t.v. system requires an elaborate and costly production chain which demands mass utilization to be justified by unit costs.

The application of television to less developed areas has especially serious problems. A t.v. satellite requires hundreds of thousands of television receivers with antennas, new large t.v. reception systems which must be financed and maintained. The experience of the 1960s in applying t.v. in new nations points to difficulties ahead. High costs led to limited numbers of receivers and the difficulties of maintenance made for low reliability where available. In contrast, the voice grade system benefits from the billions already invested by the world's common carriers. It has the potential with toll charges of tying into telephone lines easily. Where a common carrier service is lacking, the satellite ground stations may extend circuits in the local region by radio telephone, an application we feel is particularly suited to Pacific Island groups. Inexpensive voice grade satellite ground receivers may be used also to extend circuits on demand to small research groups and to individuals. We have used an effective unit no larger than a package of cigarettes, with an antenna the size of a golf stick costing $125 (U.S.). Finally, the radio broadcast stations and the radio receiver, in contrast to television transmission and reception, is widely available in developing areas. General audience materials can be supplied to broadcast stations by a service support system, for broadcast to radio receivers.

The continuing annual charges of the television system and the necessary software and receivers are enormous when compared to a voice grade system. Satellite television could become another of the well meaning efforts of the high technology countries to sell goods which saddle the less affluent with recurrent costs they cannot maintain.

It is worthy of note that the U.S. Federal Government, with all the many functions represented by a $\$300 \times 10^9$ budget, has chosen to limit itself to voice and data transmission. The Federal Telecommunication Service, the housekeeping

communication system for the several million personnel of the Federal service, has two basic elements, the voice network and the data/record network. The Peacesat model uses the natural advantages of satellite technology to provide, like the F.T.S., an inexpensive telecommunication service.

Note also that the picture telephone entry of the United States' leading common carrier was withdrawn after extensive market tests, with the sacrifice of large development costs. Corporation users found it too costly and without sufficient compensating benefits.

I am specifically referring in this discussion of television to its use in a service support system. Nothing has been said here about entertainment or change of mass attitudes. For these purposes the television motion picture has no peer. The promotion of satellites for direct television broadcasting is recognition of the fact.

The compatibility of the ATS-1 to a service support system experiment was an accident. However, because of its original weather control function it is not suitable for other than limited communication experiments. An in-depth test of a service support system would require a redesigned ATS-1 type satellite with increased power and voice grade circuit capacity.

Comparison of the ATS-1 with direct broadcast and common carrier satellites explains why there is no alternative to a properly designed service support satellite. The recently launched ATS-6 satellite was designed to emphasize direct colour television broadcast to small community receivers. The wide band, high power signals needed for moving television pictures requires that high gain directional antennas must be used with the spacecraft translator. For this reason the satellite radiates spot beams with small area coverage. The ATS-6 spot beam or 'footprint' is limited to several hundred kilometres long and 160 km wide, sufficient to cover the Hawaiian Islands, for example. The footprint can be directed or pointed through tilting of the spacecraft as is currently being done in the Rocky Mountains; therefore larger areas are served by retransmitting programmes recorded on videotape.

Transmission of television motion pictures requires a major investment in the terminal. Add the high cost of the video materials production facilities. The result is a one-to-many system. Total costs allow transmissions from a few large centres only, with a great many receiving centres in order to reduce unit costs. Unfortunately all must be within the small area covered by the satellite.

In contrast, the ATS-1, launched in December 1966, carries a narrow band v.h.f. translator able to provide widebeam coverage and, if redesigned, a number of voice grade simplex circuits for use with low cost, two-way terminals. The result is a wide area network of interactive terminals, each able to confer with the other. With peripheral equipment two-way exchange is possible by every means of telecommunication but the televised motion picture. The ATS-6 supports a one-way system for the transmission of television.

From the user's standpoint the important difference between ATS-1 and the Intelsat series of satellites is the small ATS-1 ground terminal. Terminals used with

the Intelsat global beams cost $2.5 to $4 million (U.S.). These heavy traffic units are justified for heavily populated industrial areas. Even a thin route terminal for low traffic areas will cost approximately $400 thousand. Thousands of circuits are provided with great flexibility to operating common carriers. The $5 thousand ATS-1 terminal could provide perhaps three to five voice circuits; there is a low ceiling on the available number. We are comparing a railroad system and a Land-Rover. The Land-Rover does not allow for the transport of large numbers, but it is useful for small packages and can arrive at locations out of reach of the locomotive.

We believe that the Peacesat project points to the need for an extended experiment testing the wide area, low density, service support concept. A new satellite would be required and enough time allowed to test the feasibility of a regular self-supporting system. A five year period would use the estimated life of the new satellite.

The annual cost of such an in-depth experiment would be approximately $6 million (U.S.). It is emphasized that this includes all equipment and personnel costs directly associated with the system experiment. Half of the $30 million total over five years is required for the satellite in orbit and its control during the period. Half would be required for the purchase and maintenance of ground terminals and peripheral equipment, local management of communication activities at each terminal, and project management over five years. Housing and institutional overheads are not included. All equipment is off-the-shelf and today's prices are assumed.

A major block of funds would be required initially. Subsequent use could generate income from the experimental funds of public agency participants and users, perhaps one third of the total required.

The satellite envisaged in this proposal would be so positioned to provide service to the Pacific Basin and Asian Rim countries. A proposed experimental service area is one extending from the west coast of the United States to include Burma on the east; or the satellite could be moved farther west to illuminate approximately 140° west to 80° east, including the Hawaiian Islands and India on the extremes. Domestic telecommunication systems would be available to extend service.

Satellite power would be necessary for approximately 15 simplex voice circuits. A spectrum allocation is available in the 2500–2690 MHz range, newly designated by international agreement for educational and government communications. With the International Telecommunication Union's action to reserve spectrum space for international education, the experiment is an appropriate next step to encourage use. (The frequency allocation obtained by N.A.S.A. for use of ATS-1 (149.22 MHz uplink, 135.60 MHz downlink) is well suited to small terminals. However, the action by the International Telecommunication Union designating 2500–2535 MHz downlink and 2655–2690 MHz uplink for regional and domestic educational government satellite applications assures and dictates future use of those bands. Costs of individual terminals would be less with a lower frequency

band. Nevertheless the estimated increase in terminal costs is not great and adjustment should be possible.)

A projected 75 ground terminals could be increased in number if funds and demand warranted. However, care and study would be required to avoid overloading the system. Terminals would differ in capability; there would be those with a full range of available media options and others limited to voice or voice and teletype.

Direction of the project should be by international consortium, although system operation would require a centralized management group.

Dedication of some circuits to specific social objectives might occur supported by funding commitments. This includes such activities as epidemic control, scientific data exchange, natural disaster control, agricultural information, medical education, library networking, and structured consultation among classes of health, education, and community service personnel. Both international and national agencies should find a variety of supportable uses.

At the conclusion of the experiment there would be several reasonable possibilities for obtaining the satellite relay capability for a permanent service support system. One, is shared or leased use of a satellite system designed for a traditional operator of small terminal mobile communications – public safety, transportation, or defence. Another alternative is the orbiting by Intelsat or an international carrier of a satellite series designed for small terminals and operated under a leasing policy that could adjust to low income users found among nonprofit institutions or societies with very limited money economies. As a third alternative, an independent system might be leased or purchased by the United Nations or other international agency and made available to accredited users. With costs in the range of $40–$65 million annually for the full operation of a complete world system, implementation is dependent less on the question of resources and more on convictions as to operating feasibility and obtainable social benefits. An extended experiment is essential to these judgements and to the gradual development of effective user network operations for a regular system.

The extended experiment would in a wide area service support system apply technology to two-way communications. It would begin to adjust the scales after fifty years of ever increasing emphasis on mass communication by providing the opportunity for dialogue and for self determination. Over the last decade educational technology has stressed the one-way delivery system – television broadcasting, audio cassettes, video tapes. These reinforce the Platonic view of society with programmes prepared at the top by those who know best for consumption by those at the bottom, with no provision for immediate feedback or quick adaptation.

As power shifts in the world, and then shifts again we find new incentives for dialogue, accommodation of views and joint action in response to problems. We are recognizing that whether industrial or agrarian, developed or underdeveloped, we cannot be isolated from the major problems – food, energy, population. The

failure to address these problems in any part of the world may have adverse consequences in any other part. The open channels of a service support system provides one way of extending the benefits of science and education and of reinforcing the great investments being made in training and in organized efforts to improve man's condition.

*Discussion*

You mentioned $300 000 over four years as the total expenditure incurred by the project. Presumably that is the cost of the actual equipment and operational costs of the system and not the expenditure facilitated by the use of the system for such things as the treatment of patients.

PROFESSOR BYSTROM

Yes. Cost of exchange content and facilitated public services is borne by the user.

BRENDA MADDOX

Whose idea was this marvellous thing in the first place and how long will N.A.S.A. let you use this ATS-1 satellite?

PROFESSOR BYSTROM

We are currently using the satellite along with the Rocky Mountain Experiment which is using the ATS-6 for one way television satellite but has expanded the use of ATS-1 audio capability for two way interaction. We have no assurance that we will use the satellite beyond 1 April 1975. The project was initiated by the University of Hawaii.